A COMPUTERIZED MODEL FOR ASSESSING
THE AIR CARGO THROUGHPUT
CAPABILITY OF AN INSTALLATION

THESIS

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To Captain Nancy Needham, for her patience, guidance, encouragement, and friendship, I dedicate this thesis. In actuality, Nancy initiated this research; I merely followed the path she began. Indeed, much of the work herein would not have been accomplished without her continued support. Peace Nancy, it's time to celebrate.

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And to my parents, Richard and Carole Lengyel (alias Dad and Mom), thanks for always being there. I love ya.

-- Denise Lengyel Harriott

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Abstract

Accurate capability assessment is vital to the success of the United States military forces. By ensuring that both the operational and support sectors are adequately prepared, the U.S. is better able to win, if not deter, worldwide military aggression. The costs involved in large scale deployments often restrict actual field testing of various mobility plans. As a result, it is now commonplace to "paper test" many warplans as a means of saving money. Air cargo throughput capability assessment is one area of logistics where enormous strides have been made toward developing "paper test" assessment tools.

This thesis presents an air cargo throughput capability assessment model that expands on the efforts of both the Transportation Engineering Agency and Capt Nancy Needham. It provides a computerized tool for quantifying the capability of subsystems within an air cargo transportation infrastructure.

Designed for use by managers and planners at all levels, the model is easy to apply and interpret, and requires only minimal computer hardware, software, and knowledge. The model can be used to test the air cargo transportation feasibility of existing or proposed operation and mobility plans. Additionally, results obtained from application of this model can be used as quantifiable justification for additional equipment and facilities requests and for the reallocation of existing resources.

A COMPUTERIZED MODEL FOR ASSESSING THE AIR CARGO THROUGHPUT CAPABILITY OF AN INSTALLATION

I. Introduction

Overview

The complex and dynamic nature of the international political and economic arenas has continually led to hostilities throughout the world. United States involvement in the Vietnam Conflict and more recently in the Grenada Crisis required the movement of large numbers of troops and equipment to areas that were thousands of miles away from the original point of embarkation (30:1). Similar mobilizations could be required at any time. As a result, the United States military must be in a constant state of readiness, prepared to deploy and sustain human and material resources anywhere in the world in response to any level of crisis (35:8).

Military warplanners and logisticians are tasked to provide feasible, systematic warplans identifying mobilization requirements and procedures necessary to respond to a variety of possible crisis scenarios (28:10). Additionally, the Joint Logistics Review Board has determined that the Department of Defense (DOD) planning system must "provide for a realistic appraisal of logistic resources to achieve balance between operational concepts and logistic capabilities" (17:6-5). Military exercises

such as REFORGER (Return of Forces - Germany) and TEAM SPIRIT test the military's ability to successfully carry out the procedures outlined in the warplans. Those exercises are a valuable learning experience for all involved but they are also extremely costly. To reduce expenditures, several logistics models have been developed and are integrated into the planning system (4:8;23:2A.47; 28:1).

The logistics system can be modeled using flow charts, mathematical formulas, or computer programming (1:454). Systems analysts have also used similar methods to model each subsystem of logistics. Transportation is one of those subsystems (28:3). The Military Traffic Management Command (MTMC) is tasked to evaluate the military transportation system and determine if the system can meet DOD mobilization requirements (36:3). In response to that tasking, the MTMC Transportation Engineering Agency (TEA) developed, and is using, a mathematical model to assess and quantify surface transportation capability (5;6;28:2). That model has been applied to several Army and Air Force installations and has shown both internal and external validity (7;8;12;13;18;19;28). Recently the TEA methodology was modified by Captain Nancy L. Needham (USAF) and used to determine an Air Force installation's air inbound cargo handling capability (28). This thesis yields verification and external validation of Capt Needham's methodology and culminates in a computer application of the model.

General Issue

The USAF Directorate of Transportation (HQ USAF/LET) and the Military Traffic Management Command Transportation Engineering Agency (MTMC TEA) currently advocate the use of two methodologies for evaluating a military installation's transportation system (5;28). The first methodology, designed by MTMC TEA, quantifies an Army installation's surface transportation capability (5;28:2;34). Later research resulted in a modified version of the TEA methodology that is appropriate for evaluating an Air Force installation's air cargo handling capability (28;34). Though both methodologies are useful, the latter is designed specifically for an Air Force installation's unique transportation infrastructure and forms the basis of this research. This thesis automates Capt Needham's methodology, verifies and validates the model's applicability to air outbound transportation functions, and gives warplanners and aerial port managers a means to evaluate air cargo handling shortfalls at any prescribed or proposed activity level.

Background

In 1986, Captain Nancy L. Needham (USAF) examined the Military Traffic Management Command's methodology for assessing an installation's surface transportation capability. Capt Needham researched existing capability measurements used by the Air Force and determined that a tool for evaluating an installation's air transportation

capability did not exist (28:3). In 1987, with support from MTMC TEA and HQ USAF/LET, Capt Needham concluded that the MTMC methodology could be modified and used to assess an Air Force base's air transportation capability (28:88). The methodology used by Capt Needham paralleled the TEA methodology. Both advocate the use of five distinct but inter-related steps to evaluate and quantify an installation's ability to handle cargo movement through all movement phases (5;28:31-36).

The results of Capt Needham's research were lauded by HQ USAF/LETT as "a definite improvement in our ability to assess air transportation capability" (34). However, the effectiveness and efficiency of the methodology used by Capt Needham were impaired because the procedures were not automated. As a result, data gathering techniques and computations are slow and subject to error.

Addressing the 1988 graduate candidates enrolled in the Air Force Institute of Technology's Transportation Management program, Brigadier General Clarence Lindsey (USAF) expressed the Air Force's need for both effectiveness and efficiency. He further outlined some of the major goals established by the Air Staff for the Air Force transportation community. Those goals include "creating a paperless environment for transportation" and "enhancing wartime readiness." General Lindsey advocated the use of computer automation to achieve those goals (22).

Problem Statement

The methodology currently espoused by MTMC TEA and Headquarters USAF/LET for assessing air cargo handling capability is not automated and cannot easily be used to predict handling capabilities and shortfalls at various levels of cargo flow activity. Additionally, the methodology has not been verified using air outbound cargo data and external validation has not been accomplished.

Research Objective

This thesis provides outbound air cargo handling assessment capability verification, computer application, and external validation of a United States Air Force (USAF) application of the MTMC TEA methodology for assessing air cargo handling capability. The objective of the computerized model is to provide aerial port managers and airlift warplanners a rapid, user-friendly method for determining both present and potential air cargo handling capability. Verification of the model is accomplished by inputing the data gathered and analyzed in the Needham thesis into the computer model and comparing the results. Validation of the computer model is accomplished using current data gathered from a USAF aerial port.

Investigative Questions

To automate the methodology developed by Capt Needham for assessing air cargo transportation capability, three key investigative questions must be resolved.

1. What data gathering techniques are most appropriate for a computerized application of the Needham methodology?

2. How well does the computerized model identify equipment and facility shortfalls?

3. What benefits are gained by applying computer modeling techniques to the Needham methodology?

The research techniques used to answer these questions will be described in Chapter III.

<u>Scope</u> <u>and</u> <u>Limitations</u>

This thesis provides airlift warplanners and aerial port managers a tool to evaluate the air cargo handling capability of any installation. The computer model developed will generate the information necessary to determine current capabilities and shortfalls. Additionally, the model provides users a means to assess the impact of changes in material handling resources, facilities, and cargo movement requirements on an installation's air cargo handling capability. The computer model focuses on the flow of cargo through all movement phases required at an installation. Validation of the model is accomplished using data gathered from only one Air Force installation; however, the model was verified using data previously analyzed in Capt Needham's thesis. Though applicable to any installation, users must have access to, and limited knowledge of, an IBM compatible computer. Users must also have access to a computer spreadsheet program

that is capable of importing and transforming data files written for VP-Planner Plus. This software package was used to develop the computer model and was chosen with consideration given to methodology requirements, user-friendliness, economy, and compatability with software and computer systems currently used at Air Force installations.

Assumptions

The computer model developed in this thesis is based on the assumption that the mathematical formulas and procedures prescribed in the Needham methodology are appropriate for assessing an installation's air cargo handling capability. Additionally, personnel availability is not incorporated into the model because it is assumed that the installation will acquire additional workers if necessary.

Definitions

The following terms, as defined in Capt Needham's thesis, provide continuity and promote understanding of the computerized application of the Needham methodology:

1. MTMC Transportation Engineering Agency--an activity of the Army's Military Traffic Management Command which performs analysis of transportation systems (i.e., installation outload studies), provides transportability criteria and guidance to the Department of Defense (DOD), and furnishes traffic and transportation engineering services for the DOD (2:30;3:31;28:8-9).

2. Capability--a measure of a system's ability to achieve its mission objective given specific performance criteria (1261-3;28:8-9).

3. Transportation system--the integrated and coordinated activities of personnel, equipment, and facilities necessary to sustain the systematic movement of material (5:716;28:8-9).

4. Transportation planning--the process of determining which transportation actions or capabilities are needed to accomplish a mission (5:523;28:8-9).

5. Mobilization--the process by which U.S. military forces are brought to a state of readiness for war or other national emergencies including assembly and organization of personnel, supplies, and weapons systems (5:455;28:8-9).

The following definitions are provided to enhance understanding of terms specific to the computerized application of the Needham methodology:

1. Model--a representation of an object, system, or idea in some form other than that of the entity itself used as an aid for explaining, understanding, or improving a system (31:4).

2. Computer model--a model expressed as a computer program (20:4;21:172).

3. External validity--the ability of an observed causal relationship to be generalized across persons, settings, and times (14:115).

4. Internal validity--the ability of an experimental relationship to promote conclusions that imply cause (14:115).

5. Validation--the process of testing the agreement between the behavior of the model and that of the real system (31:30).

6. Verification--the process of insuring that a model behaves the way it is intended to behave (31:30).

Summary

This chapter has established the need for continued development of the Air Force application of the Army transportation capability assessment methodology (the Needham methodology). Additionally, the research objective, investigative questions, assumptions, and terminology pertinent to this thesis were described. Chapter II contains a brief description of the two categories of planning relevant to the DOD and discusses MTMC's transportation capability assessment methodology which was designed to support the planning process. Additionally, an in-depth review of the Needham methodology is presented. The chapter concludes with a discussion of the uses, traits, and requirements of a computerized model.

II. Literature Review

Overview

This chapter presents a discussion of two methodologies for assessing the transportation capability of an installation. The first approach was designed by the MTMC TEA as a tool for evaluating an army installations surface transportation capability. That technique forms the framework for the second approach, the Needham methodology. The Needham approach is discussed in depth with emphasis given to the assumptions, data gathering techniques, mathematical formulas, and procedures. The chapter concludes with an analysis of modeling techniques and the steps involved in designing and writing a computer model.

Mobilization Planning

Accurate, detailed planning is a key element in the success of all mobilization efforts. Armed Forces Staff College Publication 1, "Joint Staff Officers Guide 1986," divides planning into two types based on the amount of time available for planning. Deliberate, or peacetime planning, is defined as "a cyclic process used when time permits" and is based on the assumption that all agencies involved will deliberately coordinate in the development of the plan (27:6-6). Time-sensitive planning, on the other hand, occurs during emergencies when detailed, time-consuming coordination is not feasible (27:6-6).

Transportation is the process of getting the right item to the right place at the right time and is paramount to the successful implementation of all mobilization plans. As such, planning officers are more involved in planning for the movement of forces and supplies than in planning for the tactical employment of those forces (27:6-5). As part of the Army's Military Traffic Management Command (MTMC), the Transportation Engineering Agency (TEA) provides the DOD with transportability criteria, guidance, and analysis, and thus plays a vital role in the plan development phase of deliberate planning (28:8). MTMC TEA uses several mathematical models to insure that the surface transportation requirements and capabilities outlined in an operation plan (OPlan) are transportation-feasible. In his article entitled "A New Methodology for Installation Transportation Capability Studies," Charles J. Davis describes a methodology developed by the TEA to determine an Army installation's ability to handle the transportation requirements specified in an OPlan (6). Davis states that the methodology has three primary objectives: 1) defining the transportation system; 2) identifying all mobilization requirements; and 3) determining the capability of the system to meet those requirements (6:1).

In October 1984, Davis presented a detailed explanation of the methodology to the 23rd Army Operations Research Symposium. His paper, entitled "Installation Transportation

Capability Study Methodology," outlined five steps required to successfully apply the TEA methodology (5). Capt Needham reviewed that paper in her thesis and succinctly identified those steps as follows:

1) define the mobilization mission and operational procedures of the installation;

2) describe the fixed transportation facilities and mobile transportation equipment, which define the transportation system;

3) define the mobilization transportation requirements;

4) determine the capability of the system; and

5) draw conclusions and make any recommendations that may be necessary to upgrade the system capability to meet or exceed requirements (28:17-18).

The TEA methodology was tested at three Army installations prior to Army-wide implementation of the assessment techniques (6). The methodology proved to have high internal validity and was subsequently applied at several Continental United States (CONUS) Air Force bases (13;18;19). The TEA methodology was, however, designed only to determine surface transportation capability. As a result, the final reports published upon completion of the base studies consistently stated that air transportation capability was not assessed (3;18;19;28:4). In an effort to correct that deficiency, Capt Needham conducted a year-long study of the methodology and concluded that a modified version of the TEA methodology could be used to measure air transportation capability.

The Needham Methodology

In her Air Force Institute of Technology graduate thesis, "A U.S. Air Force Application of a U.S. Army Transportation Capability Assessment Methodology," Capt Needham described the modifications she made to the MTMC methodology prior to measuring the air inbound cargo handling capability of an Air Force base (28). Capt Needham adhered to the five steps prescribed by MTMC; however, the type of data gathered and the subsystems measured reflected the transportation infrastructure of an aerial port. The test base was considered by Military Airlift Command (MAC) experts to be representative of a typical aerial port.

In the first step, Capt Needham defined the mobilization commitment and the operational procedures of the test base. She also identified and quantified three broad categories of cargo (pallets, break-bulk pallets, and rolling stock) handled by the port. Next, she used a random sampling of the MAC Forms 77, Aircraft Ground Handling Record, to obtain the weight and quantity data for each cargo type. Additionally, she conducted numerous interviews with experienced personnel to determine the flow pattern that inbound cargo follows from the time offload at the aircraft begins to the time the cargo exits the base perimeter. From the composite flow pattern, Capt Needham developed a flow diagram portraying cargo movement (28:37-42).

The second step in both the Needham and the MTMC methodologies was to identify and quantify facility and equipment assets on-hand, authorized, or otherwise available to the installation. Those assets included all material handling equipment (MHE), cargo breakdown and storage facilities (e.g., buildings and loading docks), roadways, and railways (28:43-49).

Next, Capt Needham identified the mobilization transportation requirement of the installation. To simplify that process, Needham divided the transportation requirements into five broad areas: material requirements based on expected cargo handling workload; receiving requirements via truck and railcar; material requirements based on the mode, size, and number of shipments expected; intraplant movement in terms of the mean number of railcars and truckloads required to support air inbound cargo movement; and the mean number of trucks and railcars required to transport all shipments to their off-station destination (28:49-70).

The fourth step involved analysis of each substation and the calculation of each subsystem's capability. The four subsystems analyzed were loading/unloading facilities, the locomotive/track network and railcar fleet, the truck/tractor fleet, and the available MHE. The formula used to determine facilities capability was:

$$CF = \sum_{i=1}^{n} \frac{W \times CV \times PT}{LT} \qquad (28:99)$$

where

CF = facility capability

CV = total vehicle capacity

LT = loading/unloading time for the activity

PT = estimated personnel productive time

i = index number of each activity

n = number of activities

W = facility utilization factor based on:

$$W = \sum_{i=1}^{n} \frac{REQ \times LT}{REQ \times LT} \qquad (28:99)$$

where

REQ = requirement for each activity

The truck/tractor capability was computed by comparing the number of vehicles available based on in-commission rates with the number of vehicles required based on the number of pallets expected multiplied by the mean number of pallets per truck.

The formula used to determine the capability of the equipment subsystem was:

$$\text{hours required} = REQ \times (LT + PT)$$

The result was then compared to the hours each item was available. To compute the equipment availability rate for each item of equipment (e.g., 40K loaders), the number of items on hand was multiplied by the in-commission rate for that item. When all capabilities were computed, a comparison table was built to reflect the availability and the

requirement for each item. Analysis of this table yields the "weak link" in the subsystem (28:81-82). In step five, Capt Needham analyzed the system in its entirety and made recommendations to appropriate test base personnel. Her recommendations included identification of shortfalls and possible corrective actions (28:80-85).

Capt Needham made three major assumptions in her study. First, she assumed that an adequate number of personnel would be available to support the system requirements (28:8). This assumption allowed her to overlook the personnel subsystem when computing the installation's capability. Second, she, like MTMC, assumed that productivity of the system and each subsystem therein was based on a 20-hour, three-shift operation (28:8). Finally, Capt Needham assumed that the random sampling techniques employed to determine the current number of shipments, the weight of each shipment, the number of pallets in each shipment, and offload times yielded results representative of the actual data (28:8).

Building a Model

The Role of Models in Strategic Planning. Modeling is not a new phenomenon. Analysis of history reveals that the use of models as a symbolic representation of reality was common even among pre-historic men (32:1). The Random House College Dictionary defines a model as "a representation, generally in miniature, to show the structure or serve as a

copy of something" (32:1). In his book What If...? A guide to Computer Modeling, Tom Simondi expands on the Random House definition to include the use of mathematical symbols as a representation of reality (32:3). Simondi advocates the use of computer models in virtually all fields of science and management because they are more versatile than non-automated models. Computer models allow the user to describe an object and then rapidly and easily manipulate that object under specific test conditions (32:8). Additionally, Simondi recognizes the utility of computerized spreadsheet packages when developing models used in a variety of management situations (32:37-39).

Robert Shannon, author of System Simulation, The Art and Science, suggests an even broader view of models. Shannon states that "a model is a representation of an object, system, or idea in some form other than the entity itself" (31:4). Further, Shannon explains that a model need not be an exact replica of the subject (31:4). Instead, the model may be scaled up or down and include all or a portion of the variables affecting the subject (31:4-5). Shannon advocates the use of modeling in a variety of situations (31:4). Simondi agrees (32:3-10). Put succinctly, Shannon writes that the purpose of a model "is usually as an aid in explaining, understanding, or improving a system" (31:4). Continuing his quest for commonality among models, Shannon lists five basic uses for models:

1. As an aid to thought.
2. As an aid to communication.
3. For purposes of training and instruction.
4. As a tool of prediction.
5. As an aid to experimentation (31:5).

Again Simondi agrees, while distinguishing between prediction and forecasting. Prediction involves rational judgment; forecasting is a structured exploitation of past data into the future (32:16).

<u>Spreadsheets as the Median for Models</u>

In "A Guide to Spreadsheets Using VP-Planner," Norman Sondak defines a spreadsheet as "the basic document for capturing business data" (33:1-4). Further, he states that "the spreadsheet's tabular format is a very natural way to present many different types of business and scientific data" (33:1-4). Computer spreadsheets have a distinct advantage over paper spreadsheets as they allow automatic recalculation of data when changes are made to the data base (33:1-5). This capability saves the user time and eliminates the possibility of human error when performing calculations. Spreadsheets also differ from, and have an advantage over, database management programs in that mathematical and statistical calculations can be programmed into and performed by spreadsheet software packages.

Many different computerized spreadsheets are available for use on both mainframe computers and personal computers (33:1-3). In choosing a software package to use as the median for computerization of the Needham Methodology,

several criteria were considered. First, the spreadsheet had to be compatable with computer systems currently used throughout the DOD. Additionally, the spreadsheet had to be easily interpreted by the major spreadsheets currently in use throughout the DOD. Further, the software had to be user-friendly; exhibiting menus and help screens to aid the modeler and users. Finally, the spreadsheet had to allow use of macro functions as a means of moving rapidly throughout the spreadsheet.

VP-Planner Plus (VPP) met all of the above criteria and was thus chosen as the spreadsheet package used to build the model for this thesis. A model built using VPP can be retrieved and interpreted by rival spreadsheets (i.e., LOTUS 123, VisiCalc, etc.) using the file import command (33:6-26). Additionally, VPP can retrieve and translate data from many common database management software packages (e.g., dBase, rBase, etc.) (33:6-26). Those features increase the utility and economy of the package as models developed using VPP do not have to be used exclusively with VPP software.

Characteristics of Models

Just as models have common purposes, good models also have certain common characteristics. Building Financial Decision-Making Models, by Donald A. Moscato lists four properties necessary in a good model. Those properties are simplicity, conversationality, flexibility, and completeness (25:10-11). Though his verbiage differs, Simondi agrees

with Moscato. Simondi explains that simplicity is necessary in almost all models because complexity often causes both the modeler and the user to lose sight of specific desired outcomes. Additionally, complex models often incorporate extraneous variables, making it difficult to establish the validity of the model (25:15).

Conversationality is the second key ingredient in good models. This trait allows the user to freely interact with the model and facilitates interpretation and use of the model and the model outcomes. However, Simondi warns that users should not have easy access to variables that are likely to remain constant, lest the results become unclear (32:15).

The third characteristic necessary is flexibility. This property is particularly useful when conducting sensitivity analysis on the model (32:16). The user often wishes to know what the effect of changing a variable will be on the outcome. A flexible model allows a variety of changes to be tested, yet the validity of the outcome is not affected.

The final characteristic is completeness. The model must do what it was designed to do and must measure or reflect what it was intended to. Simplicity should not be sacrificed for completeness, nor should completeness be sacrificed for simplicity. The modeler should develop a proper mix of the two characteristics in the model to insure

accuracy. In short, modelers should make the model as complete as possible while simultaneously striving for simplicity (32:16).

Shannon is not quite as explicit as Moscato and Simondi in elucidating the characteristics of models. He views model building as an "intuitive art" with vague guidelines established only to give the novice modeler direction (31:19). According to Shannon, modeling is an "evolutionary process" that begins with a simplistic design and is gradually enriched and elaborated on by the modeler (31:19). Like Moscato and Simondi, Shannon points out that flexibility and modeler-user interaction are important in the success of all models (31:21). Shannon emphasizes the importance of these two ingredients in promoting trust between the modeler and the user and in establishing the user's faith in the accuracy of the model.

Guidelines for Model Building

Though models may differ in technique (e.g., format, use, etc.), Simondi lists several guidelines that may be followed regardless of the desired end product. Simondi's 10-step process was designed as a guide for developing models using spreadsheets. Shannon does not list specific steps to follow, yet analysis of his recommendations reveals that he advocates a process similar to Simondi. A thorough understanding of each of Simondi's steps makes designing, building, and implementing a model less difficult.

The first step proposed by Simondi is to determine if the subject can be modeled effectively. This step involves defining a broad purpose, determining the degree of model accuracy required, deciding what variables will be included, and how each variable will be manipulated (i.e., mathematical formulas, statistics, deletion, etc.). Also, the modeler and user must decide how closely the model should represent reality (32:23).

The second step is to explicitly state the problem. This statement should include all assumptions and pertinent information but should not include extraneous data or descriptions. A good problem statement is precise yet accurate. Simondi views this as the most difficult and most important step. Without a clear statement of the problem, the model may not yield the desired output (32:24-25).

Next, the modeler must decide exactly what type of data should be produced by the model and the desired format of that product. In a sense, this step is an extension of the problem statement because it outlines the desired goal of the model which in turn solves the problem. Step four is closely related also. In this step, the modeler must define what formula(ae) are needed to generate the desired end product (32:34).

In step five, the modeler designs the computer worksheet. Shannon recommends developing a flow chart of the problem prior to actually designing the worksheet. A

flow chart gives the modeler a chance to organize thoughts, ideas, and requirements thereby facilitating worksheet development. After the flow chart is completed, the modeler formats the computer worksheet. Formatting may involve developing a template or merely labeling rows and columns on the worksheet (32:34).

Step seven is a preliminary verification of the accuracy of the formulas included in the model. Shannon recommends using a hand calculator to test the worksheet format of the formulas. This step saves time and helps insure the accuracy of the model's outcome (32:34).

Steps seven, eight, and nine are all accomplished using the computer. Formulas are written into the worksheet in step seven. In step eight, the data used to manually test the formulas are input into the worksheet and the results are compared to the results that were obtained manually. Errors noted in this step are corrected in step nine (32:34).

Finally, when the modeler is satisfied with the accuracy of the model, actual subject data is tested using the model (32:34). This step may involve a single application of the data or it may include a sensitivity analysis. Conclusions can be drawn from the model outcome and the user can recommend changes based on the outcome of the sensitivity analysis.

Regardless of the techniques used to build a model, the outcome should be the same: an accurate, complete representation of a problem and a variety of possible solutions to that problem. The advantages afforded by models, both physical models and computer models, are numerous. Specifically, models can greatly reduce monetary expenditures and conserve time, equipment, and manpower resources.

Summary

This literature review briefly explained the importance of proper planning for National Defense. Two types of planning, time-sensitive and deliberate, were discussed with emphasis placed on the need for thorough deliberate planning. Next, the MTMC TEA model for assessing the surface transportation capability of an installation was summarized as a means of establishing the origin and purpose of the Needham methodology. Following the MTMC methodology review was an in-depth survey of the procedures, formulas, assumptions, and limitations of Capt Needham's model. That review was followed by a discussion and brief analysis of three approaches to computer model building. Included in that analysis was a detailed description of the steps involved in building a model. Those steps were presented as a means of reviewing the techniques used in this thesis. This thesis provides a computerized spreadsheet application of the Needham methodology; therefore the advantages of computerized spreadsheets over manual calculation methods

were highlighted. The characteristics of VP-Planner Plus, the spreadsheet package used in this thesis, were also identified. Since the Needham tool for assessing an installation's air cargo transportation capability is not automted, the next chapter will describe the methodology used to develop and apply a computerized spreadsheet application of the methodology.

III. Methodology

Overview

This Chapter describes the data gathering techniques used to answer the investigative questions identified in Chapter I. Those questions were derived from the research objective identified in Chapter I and incorporate many of the methods prescribed in the Needham methodology.

Research Technique for Investigative Question One

The first investigative question identified was "What data gathering techniques are most appropriate for computerizing the Needham methodology?" A primary objective of all models is to promote direct and continuous interface between the model and the user. To meet this objective, a site survey of the designated test base was conducted to determine what a typical user's requirements and expectations were, and what data was maintained by, or readily available to, installations where this model could be applied (25:10-11;32:15). Additionally, test base personnel and the research advisor agreed that the model should be built to fit the format of the existing data bases. As a result, the spreadsheet formatting and data gathering for those phases of this thesis were accomplished simultaneously. As discussed in Chapter II, the spreadsheet package chosen for this thesis was VP-Planner Plus.

In performing this study, every attempt was made to adhere

to the methodology developed by Capt Needham. As such, it is appropriate to identify the investigative techniques used by Capt Needham and identify deviations made during this research.

For each of the five steps prescribed in the Needham methodology, a variety of investigative techniques were used. In completing the first step, defining the installation mission and operations, Needham reviewed several installation documents (i.e., command and base regulations, squadron publications, base and wing histories, etc.) (28:38). Interviews were then conducted with personnel assigned to or affiliated with the test base (28:39). Those interviews resulted in an enhanced view of the local mission and the identification of three broad categories of cargo handled by the installation (pallets, breakbulk pallets, and rolling stock). A random sampling of local forms (e.g., MAC Forms 77 and station monthly workload reports) resulted in quantification of each of the three categories of cargo. Additionally, when quantifying the cargo types, Capt Needham used the "80:20 rule" recommended by two local planning experts (28:40). This rule assumes that 80 percent of the cargo tonnage to be airlifted during a mobilization will be palletized and 20 percent will be rolling stock (28:40). Finally, Capt Needham used both personal interviews and observation to develop a diagram reflecting the flow of air cargo within the confines of the base.

Local forms and MAC Forms 77 are still used by installations to record airlift data; however, the data is then transferred to the installation's ADAM III computer terminal and transmitted to a central data collection facility at the cargo analysis branch of HQ MAC (TRKA). Computer programmers at HQ MAC/TRKA have the ability to retrieve and manipulate the aggregate data upon request. According to MSGT Patrick Jergensmeyer (USAF), a systems analyst assigned to HQ MAC/TRKA, data retrieval is not a difficult process once specific data is requested. The data requested for this thesis consisted of a consecutive six-month history of:

1. the total cargo tonnage airlifted, by day, by type of aircraft;

2. the total weight and number of pallets lifted, by day, by type of aircraft;

3. the total weight and number of breakbulk pallets handled, by day, by type of aircraft; and

4. the total weight and number of pieces of rolling stock lifted, by day, by type of aircraft.

Currently, MAC does not account for surface cargo movement via a central data base system. As a result, a random sampling of local cargo handling forms was used to determine the capability of the surface freight receiving activity.

In steps three and four of the methodology, Capt Needham applied the mathematical and statistical formulas developed by the TEA and reviewed in Chapter II. Though the formulas required only basic mathematical operations, the process was slow and cumbersome because a hand calculator was used to perform all calculations (29). To speed the process, reduce the possibility of computation errors, and increase user utility of the methodology, a computer model was built in this study. Using VPP, the model was designed to store all data and perform on-line calculations as data was entered. The steps used to design the model were those recommended by Simondi and reviewed in Chapter II.

Step five of the assessment methodology involved a comparative analysis of the equipment and facility capability and the requirements of those activities. The comparison allowed identification of shortfalls within those activities. After conclusions were drawn, a "what if" analysis was accomplished to provide a quantitative basis for the recommendations made.

Research Technique for Investigative Question Two

The second investigative question asked was "How well does the computer model identify equipment and facility shortfalls?" To answer this question, an Installation Daily Capability Summary table was built into both the inbound and outbound portions of the model. Those tables reflected the

standard capabilitv and requirements (based on the current workload) and the surge and sustained mobilization capabilities and requirements (based on the cargo flow anticipated in the scenario tested). Review of those tables allowed visual comparison of the assets available with the assets required. Any item that had a larger requirement than capability was designated a shortfall.

Research Technique for Investigative Question Three

The final investigative question identified in this thesis was "What benefits are gained by applying computer modeling techniques to the Needham methodology?" As mentioned in Chapter I, one of the goals of the Air Staff is to "create a paperless transportation environment. This study supports that goal. Additionally, an inherent advantage of computers is their accuracy. As long as the data is entered correctly, the output will be accurate. Upon completion of the verification and validation phases of the model building process, the model and data base will be distributed to Capt Needham, MTMC TEA, and the research advisor for their review and evaluation. Comments will be solicited from each pertaining to the user-friendliness and application time.

Summary

This chapter has decribed the methods used to develop a computerized spreadsheet application of the Needham model

and the data gathering techniques appropriate for that model. The research techniques employed were literature review, observation, personal interviews, mathematical testing, and sensitivity analysis. Chapter IV of this thesis describes the development of the computer spreadsheet.

IV. Model Description

Overview

This chapter provides a discussion of the design and development of the Needham methodology in accordance with the ten model building guidelines recommended by Simondi and the five steps prescribed in the Needham methodology. First, a brief review of the model's purpose is given. That review is followed by a description of the template files comprising the model, their design, scope, and limitations. The chapter concludes with step-by-step review of Simondi's and Needham's steps as applicable to the design and development phases of this study.

Model Purpose

The two template files comprising the model developed for this research provide an enhanced and automated application of the Needham methodology for assessing the air cargo throughput capability of an installation. When the methodology was originally developed and applied, all calculations were manually accomplished using a hand-held calculator. This thesis reduces the possibility of calculation errors and speeds the assessment process via use of two spreadsheet-based templates. The resulting model, therefore, allows more rapid and accurate quantification of both the inbound and outbound air cargo throughput capability of an installation.

Model Design

The two template files built for this model were designed on an IBM compatable computer and require a minimum of 640 kilobytes of memory. Both the inbound and outbound files were developed using VP Planner Plus (VPP). That spreadsheet package was chosen based on its compatability with spreadsheet packages commonly used in USAF field units, and on its ease of application (user-friendliness). The files can, therefore, be used with any spreadsheet package that can use or interpret files with a ".WKS" extension (suffix). Further, the commands used by VPP are similar to those used in LOTUS 123. As a result of the computer brand and spreadsheet package used, the template files can be used with most computer systems and spreadsheet packages currently available to field units. Because of the length of both template files, two floppy disks are required (in the absence of a hard drive). However, users are advised to make backup copies of all disks and model applications. Those backup copies serve two purposes. First, inadvertant erasure of one of the primary disks will not leave the unit/user without copies of the template files; and second, if all data is input into, and saved on, a primary template disk, beginning anew will not require tedious, careful erasure (and subsequent loss) of data already input.

As the initial purpose of this thesis was to test the methodology's applicability to outbound throughput

assessment, the outbound template file was developed first and is the primary focus of further discussion and description in this chapter. However, after the accuracy of the outbound template was tested by inputing test base data, an inbound template file was developed and model accuracy verified by Capt Needham and also by inputing test base data. Though instructions for use and interpretation of the templates focus on the outbound application, most of that information is applicable to both files. Additionally, deviations in data requirements for each file are appropriately noted and discussed.

Model Description

To facilitate ease of use and interpretation, each template file consists of a map, menu, several data tables, and a capability summary table. To avoid input of data into cells containing formulas or preset data, all cells not requiring user interaction are protected via application of the spreadsheet cell protection option. Preset data (e.g. standard pallet weight) are based on the standards prescribed by HQ MAC experts and implemented in most field units. To allow customizing of the model by individual units, instructions on modifying the preset standards are given in this chapter.

Implementation of Simondi's and Needham's Steps

Simondi's Step One. Determine if the subject can be modeled effectively. To complete this step, both MTMC

applications of the Methodology and the Needham methodolgy were thoroughly examined to insure that consistancy with the methodology could be obtained using a spreadshhet package. MTMC has developed and is using a computerized application of the original methodology, while Capt Needham successfully modified and applied the methodology to a USAF installation. After several in-depth discussions with the thesis andvisor, it was decided that an attempt should be made to computerize the Needham version of the MTMC methodology.

Simondi's Step Two. State the Problem. This step was accomplished and documented in Chapter I of this thesis. The problem statement was based on discussions with Mr. Davis at MTMC, Capt Needham, Mr. Tom Spade at Hq USAF/LETT and the thesis advisor, and on a thorough breakdown of the Needham Methodology. In brief, the problem statement identified two deficiencies with the Needham methodology:

1. The Needham application is not computerized.

2. Verification of the applicability of the Needham model to air outbound cargo throughput assessment was not accomplished.

Simondi's Step Three and Four. Decide what data output should result from the model and the format that the output should take. The purpose of the methodology, to define the installations transportation requirements and capability and to make recommendations to upgrade that capability, provided guidance for accomplishing this step. Additionally, the

output of the Needham application was used as a basic framework for model output. The key requirements of the output were completeness, understandability ("conversationality"), and compactness. The capability of each subsystem under three conditions (standard or current, surge mobilization, and sustained mobilization) had to be illustrated. Further, the format of the end results had to allow simultaneous comparison of the capability of all subsystems so that the system's weak link could be identified. To accomplish those objectives, a series of tables were developed to facilitate data entry. The final table provides a summary of the results derived in all previous tables. A spreadsheet macro was integrated into each model template to increase the ease of printing the summarization tables.

Simondi's Step Five. Design and format the computer worksheet. As discussed earlier, the spreadsheet package chosen was VP Planner Plus. In the Needham application, a flow chart depicting cargo movement throughout the installation was developed. That flow chart was analyzed and used as a guide for gathering data. However, because of the interactive nature of the formulae used in the computerized model, no meaningful results can be obtained until all data is entered into the template. Thus, the order of data entry is not critical. This trait only enhances the overall applicability of the computerized application, as it allows users to enter data as it is received and to perform data updates as required.

Simondi's Step Six, Seven, Eight, and Nine. Enter the formulas into the model, enter test data into the model, compare the computerized results to results obtained manually, verify the accuracy of the formulae, and make corrections as necessary. For this application, each of these steps involved computer interaction; therefore they were accomplished simultaneously. As each of the Needham formulas was entered into a template table, its accuracy was verified by inputing data gathered in the Needham thesis and comparing the results. Preliminary corrections were made as necessary. However, because of the internal operational complexity of the template files, complete verification of accuracy could not be accomplished until all formulas had been programmed and all Needham data entered.

After accuracy of the formulae was assured, the model was ready for use with test base data. However, at this point in the research process, application of the five steps prescribed in the Needham methodology was appropriate. Step ten in Simondi's model building process, testing actual subject data, correlates to steps two through five of the Needham methodology, therefore its implementation will be discusssed along with the appropriate Needham steps.

Needham Step One. Define the mobilization mission and operational procedures of the installation. This step requires a detailed description and understanding of the installation's operational mission and procedures. To avoid

inadvertant identification of the test base, that description is not included in this thesis. Additionally, it was not the intent of this thesis to assess a particular installation's capability. Rather, the purpose was to develop a computerized model that could be used at any installation to assess the air cargo throughput capability. Suffice it to say that the installation tested is involved in typical aerial port activities (i.e., on/off loading aircraft and trucks, processing, documenting, and warehousing cargo, and providing guidance and expertise during worldwide mobilizations and deployment).

As in the Needham model, the cargo types handled at the installation were pallets (cargo loaded on a 463L pallet and destined for the same location and not requiring rehandling en route to the consignee), breakbulk pallets (463L pallets comprised of cargo destined for different locations and requiring "breakdown" or rehandling prior to reaching the consignee), rolling stock and outsize/oversize cargo. Also consistant with the Needham application, measurement of outsize/oversize cargo throughput capability was beyond the scope of research because accurate information concerning the types, weights, and number of pieces were not available.

Interviews with test base personnel and personal observation resulted in the development of a flow chart depicting cargo flow operations. Comparison of that flow chart with the flow chart developed in the Needham thesis

revealed that the outbound flow is the reverse of the inbound flow. Those possessing a working knowledge of aerial ports confirm that the similarity is not accidental; rather the system is designed to be a sequential process common to all installations with all cargo flows. Some minor procedural or equipment deviations are usually apparent (e.g., customs requirement or the use of unusual cargo movement equipment similar to an elevated transfer vehicle) but do not impact the overall sequential process. Users needing pictorial representation of the cargo flow of the test base are referred to the flow chart contained in the Needham thesis (Nancy:42).

Simondi's Step Ten and Needham Steps Two through Four. Apply actual data to the model. These steps all involved computer interaction. Required data, as identified in the Needham thesis and listed earlier in this chapter, were gathered first. Next data entry of both the standard (actual) workload and the mobilized workload (as identified in the scenario) was accomplished.

In conformance with step three of the Needham methodology, the transportation requirements were based on a worst case scenario. That scenario involved the handling of 2 C-130, 28 C-141, 9 C-5, and 2 each wide and narrow body aircraft each day for a 30 day period. The total thirty day tonnage requirement was 45600 short tons.

Step four of the Needham methodology, which is to identify the capability of the transportation system, is literally accomplished via the push of a button. Once data entry is complete, the function 9 [F9] key is pressed to initiate recalculation. When recalculation is complete, the individual subsystem capabilities are reflected in the data tables pertaining to that subsystem and the Installation Daily Capability Summary template table summarizes the results. An in-depth discussion on the interpretation of that table is presented in Chapter V under the subheading "Interpreting the Template".

Needham Step Five. Draw conclusions and make recommendations. Conclusions and recommendations will vary for each installation using the model. The only table that need be reviewed is the Installation Daily Capability Summary. Review of this table allows comparison of the installation's capability with the requirements. If the requirement of any subsystem exceeds the capability, a shortfall may exist. Personnel analyzing the table should be familiar with all procedures and operations of the installation, as it is often possible to substitute one subsystem with another (e.g., 25K-loaders can often be used in place of 40Ks etc.). Additionally, it should be remembered that the results presented in the summary reflect a worst case scenario. Only personnel familiar with the

daily operations of an installation can determine if the worst case shortfalls should be considered limiting factors.

After test base data was entered into the model, conclusions were drawn, a sensitivity analysis was accomplished, and recommendations were made. Briefly, the installation has potential shortfalls in the truck dock and 4K forklift subsystems. Further conclusions, a discussion of the sensitivity analysis and, recommendations are presented in-depth in Chapter V.

Summary

This chapter described the design and development of the computerized application using Simondi's model building guidelines and the five steps prescribed in the Needham methodology. Chapter V describes the application of the model to the test base and includes instructions for using and interpreting the model and model output.

V. Sample Application Using Test Base Data

Overview

This chapter provides a discussion of the model's development and application using data gathered from the selected test base. Included in that discussion are a list of the data requirements and in-depth instructions for template start-up and data input. Next, a discussion on template file interpretation and analysis is given. That discussion is followed by a summary of the findings derived from input of test base data into the model. The chapter concludes with a discussion and example of the "what-if" applications of the templates.

Model-Specific Terms

1. Actual Data - data based on the unit's current, peacetime workload (synonomous with standard data).

2. Capability - the workload level a unit can successfully accomplish based on current equipment and facility assets.

3. File (or filename) - a name given to each template and each application of the templates facilitating differentiation between data sets.

4. Mobilized Data - data based on initial deployment/ redeployment requirements specified in the operation plan or other scenario being analyzed (synonomous with surge mobilization).

5. Model - refers to the two template files (one each inbound and outbound) in this thesis developed and based on the Needham methodology for assessing the throughput capability of an installation.

6. Requirement - the workload level planned for, or expected of, a unit based on a specified mobilization or sustainment scenario.

7. Spreadsheet - the computer software package used to develop model templates and perform calculations on, and manipulation of, input data.

8. Sustained Mobilization - the expected workload at an installation (following initial deployment operations) in support of prolonged military operations.

9. Surge Mobilization - the planned or expected workload in support of the initial movement of troops and equipment specified in a a wartime, contingency, or other mobilization plan.

10. Template File - the complete set of data tables (template tables) for either the inbound or outbound portion of capability assessment model. Each of which requires one computer disk and contains the 42 tables described herein.

11. Template Table - each of the data tables located in the template files.

12. User - the individual inputing data into a template.

Hints for Using the Spreadsheet

Start-Up Procedures.

1. Boot the computer.

2. Install the spreadsheet software. If VPP is used, place the disk in the disk drive, type "VPP" (no quotes necessary), and press the <enter>/return key.

3. Choose the desired template disk or disk containing previously entered and saved data and place it in the desired disk drive.

4. When the "READY" sign shows in the bottom right corner of the computer screen, type:

/FR(drive name where the template is located):(filename)

example: /FRA:outboundt

The "/" will display the VPP spreadsheet menu. "F" is the designator for performing file operations. "R" signifies file retrieval. "A" specifies that the requested file will be located in the "A" drive. The colon (:) separates the drive name from the filename, and "outboundt" is the name of the template used to perform outbound capability assessment.

5. Stand-by. The file retrieval takes approximately two minutes. When the "READY" sign is shown on the bottom right corner of the screen, movement around, and input to, the template/file can be accomplished.

Moving Around a Template or File. Movement around a file in use can be accomplished by using the arrow keys (up, down, left, or right), the "HOME" key, or the function 5 [F5] key.

Arrow Keys. Depressing any one of these keys a single time will move the cursor one cell (block) in the designated direction. Continually pressing the key provides rapid movement in the specified direction until the key is released.

"HOME" Key. Pressing this key moves the cursor to cell A1 and displays the template menu.

Function 5 Key. ([F5]) This key, when used in combination with a cell reference, moves the cursor to the cell designated. For example, pressing [F5] A40 will move the cursor to cell A40.

Inputing Data. Data can be entered into a template loaded in the computer using either the number keys located above the typewriter keyboard or the number keypad (generally located to the right of the typewriter keyboard). To use the numbers above the keyboard, press the desired number(s) followed by the <enter> key. To use the number keypad, insure that the "numlock" key is locked on (if applicable) then enter the desired number(s) followed by the <enter> key. Users should only attempt to enter numbers into cells that are empty (or contain a number previously entered by a user), as other cells in the table deny user access via cell protection. To remove the protection of a cell, refer to the subtopic in this section entitled "Protecting/'Unprotecting' Cells".

Recalculating Data. Because of the complexity and interactive nature of the templates and formulas therein, the spreadsheet recalculation function should be set to manual operation. This setting speeds up data entry because calculation will only be performed on command rather than each time a number is entered. To inititiate recalculation, press the function 9 ([F9]) key. Data recalculation takes approximately one and one half minutes to complete. While recalculating, no other operations can be performed on the file. Additionally, the "CALCULATING" sign will flash at

the bottom of the screen. When the "READY" sign returns to the bottom right corner of the screen, normal operations can be resumed. Though not absolutely necessary, it is a good practice to recalculate data prior to saving a file.

"Error" Readings. When an improper operation or entry is attempted, an "ERROR" sign will flash in the bottom right corner of the screen. This reading may appear for numerous reasons and an in-depth discussion is beyond the scope of this thesis. However, users are advised to press the "escape" ([esc]) key and attempt the operation/entry again. If the "ERROR" sign flashes again, refer to the spreadsheet user manual.

Error ("err") Readings Inside the Tables. Many of the cells inside the file tables initially display an "err" entry in them. Those readings should not alarm users as they will "go away" when all necessary data has been entered into the file and recalculation is performed.

Protecting/"Unprotecting" Cells. To avoid inadvertant erasure of preset entries and formulas, all cells not requiring user interface have been protected; prohibiting entry of data. Every attempt was made during design and testing to use data considered by MAC experts to be representative of actual and planned data. However, to increase the field applicability of the model, users have the option of removing cell protection and customizing the preset data. "Unprotection" requires the following steps:

1. Type /WRU

2. The computer will prompt for the range to be unprotected

3. Enter the desired range and press <enter>

   example: /WRU A40.K47

   This entry will remove protection from cell A40 through cell K47.

Users are encouraged to use extreme caution and sound judgement prior to affecting changes to either of the templates. One misplaced number or mathematical symbol will cause all related cell operations to be inaccurate; thus jeapordizing the accuracy of the final output. Additionally, if changes are made to a preset cell entry or formula, users are urged to immediately reapply cell protection. This will insure that the newly entered data is not erased. To protect a range of cells, the following steps should be accomplished:

1. Type /WRP

2. The computer will prompt for a range of cells to protect

3. Type in the desired range and press <enter>

   example: /WRP A40.K47 <enter>

   This entry will apply protection on cells A40 through cell K47.

Saving and Renaming Template Files. As a means of saving a template file free of installation data, the filename should be changed prior to file saving and the template file then saved on a new disk. Once installation data has been entered on a template table, the template file should be renamed with the following procedures:

1. Remove the template disk from the disk drive.

2. Insert a blank, formatted disk into the now empty disk drive.

3. Type: /FS

4. The computer will prompt "FILE TO SAVE" and list the filename originally loaded and currently in use.

5. Type in the drive where the new disk is located, followed by a colon and the new filename desired. Press <enter>.

example: /FS
FILE TO SAVE: A:OUTBOUND <enter>

The file will be saved to the "A" drive under the filename "outbound".

6. Because the template files are so large, computer saving operations take approximately two minutes to complete. Do not remove the disk or attempt any data entry or operations until the "READY" sign reappears in the bottom right corner of the computer screen.

Resaving a Data-Filled File. Each time a data-filled file is updated, the file must be saved or the changes made will be lost. To save such changes, type "/FS" (no quotes). The filename originally used to load the file will be prompted. If the same filename is desired, press the <enter> key and filesave operations will occur, taking approximately two minutes to complete. If a different filename is desired, refer to the subtopic in this section entitled "Saving and Renaming Template Files".

Printing a Table. Due to the size of the templates and many of the individual template tables, printing must be accomplished on a table-by-table basis. To print a table to a printer, the following steps should be accomplished:

1. Insure that the printer is set up to print IBM compatable print codes (refer to printer user manual).

2. Type /PPR

3. The computer will prompt for a print range.

4. Enter the range to be printed followed by the <enter> key.

example: /PPR A40.K47 <enter>

5. Insure that the printer is on-line.

6. Type: G (this is VPP shorthand meaning "go").

7. When printing is complete, type: Q (for quit).

Some tables are too large to print in standard type on 8 1/2" X 11" paper. If printing of those tables is desired, refer to the spreadsheet and printer user manuals.

To facilitate interpretation of the template file results, the Installation Daily Capability Summary can be printed to a printer by typing [CTRL] [F1]. A predefined macro has been established allowing this unique printing option. It was not feasible to develop similar macros for all the template tables, therefore printing tables other than the summaries must be accomplished as described above.

Required Data

To speed the process of data input, users should obtain the below listed unit-specific data prior to beginning template use. It is not necessary that all input be made in one session, as file save operations can be accomplished as required. However, the possibility of user error diminishes when all data is entry accomplished concurrently.

1. A recent six (6) month, monthly aircraft handling history (refer to Mac Forms 77, Mac Forms 7107, and computer printout available on request from HQ MAC/TRKA) to include:

a. The number of C-130's. C-141's, C-5's, wide-body, and narrow body aircraft handled <u>and</u> containing cargo.

b. The number of pallets by aircraft type.

c. The total weight, in tons, of pallets by aircraft type.

d. The total number of breakbulk (brkblk) pallets by aircraft type.

e. The total weight, in tons, of breakbulk pallets by aircraft type.

f. The total number of pieces of rolling stock by aircraft type.

g. The total weight, in tons, of rolling stock by aircraft type.

2. The airfield capacity (MOG) by aircraft type.

3. The mean (average) on and offload times by aircraft type.

4. The freight and pallet storage capacity available (in square feet and number of pallet positions).

5. Truck handling data to include:

a. The total number each of flatbeds and vans handled.

b. The total weight (tons) and number of pallets received.

c. The total weight and number of loose pieces and/or breakbulk pallets received by truck type.

d. The total weight (tons) number of pieces of rolling stock received.

6. The number and in-commission rate of computer terminals.

7. Materials Handling Equipment (MHE) data to include:

   a. The total number of each type MHE assigned
   b. The total number of each type MHE available.
   c. The in-commission rate of each type MHE assigned.

8. Mean round trip transit times for cargo movement from:

   a. The aircraft to staging/storage.
   b. Storage to the pallet breakdown area.
   c. Storage to the truck docks.
   d. The pallet breakdown area to the truck docks.

Data Entry

To facilitate further use of this model, in-depth instructions for data entry are presented here. The order of data entry into the computer does not effect the final outcome. However, the order used as explanation herein is recommended as it follows a progressive flow beginning with "air" relevant information, moving to surface data followed by facilities data and materials handling equipment. Additionally, actual and mobilized data need not be entered simultaneously in each table prior to moving to the next table. In fact, it is recommended that all actual data be entered into the template prior to inputing any mobilized data. This will help avert user entry error.

Thorough understanding and analysis of each table in the templates is not necessary, as the final table in each template (the Installation Daily Capability Summary) provides a complete summarization of the capability of all subsystems analyzed. Therefore, to avoid confusion caused by unnecessary inclusion of specific formulas in each table,

only the information required to perform the installation analysis via the inbound and outbound templates is presented here. Those interested should refer to earlier chapters of this thesis for a detailed description of the methodology and formulas used in designing this model.

Analysis Timeframe. Always begin a work session by ensuring that this table has the appropriate numbers entered in it. To access this table, type [F5] A40. Use the arrow keys to move to the desired cell and make the appropriate entry. If an entry is incorrect, type in the new entry and press <enter>. When all entries are correct, move to the next table. To eliminate fluctuations in cargo flow due to yearly seasons, mobility excersizes, etc., it is recommended that a six month (180 day) actual history, a one month (30 day) mobilized plan, and a five month (150 day) sustained mobilization plan be used as the analysis timeframe. Note: Because many of the template table formulas use this information to perform a calculation, all cells in this table MUST have a numerical entry or many of the formulas in the file will not function properly!

Cargo Breakdown. There are six (6) of these tables. (It is assumed that a current six month history is adequate for, and will be used in, attaining a numerical "picture" of the installation's workload.) The first breakdown (template table 2) includes cells for the first month's actual data and the one month of surge mobilization data. The

remaining five cargo breakdown tables (template tables 3 through 7) include cells for the remaining five months' actual data and five months of sustained mobilization data. Data required for these tables are:

1. The number of aircraft by type (actual and mobilized/sustained).

2. The number and total weight (tons) of pallets by aircraft type (actual).

3. The number and total weight (tons) of breakbulk (brkblk) pallets by aircraft type.

4. The number and total weight (tons) of rolling stock by aircraft type.

Use the arrow keys to move within and between each of the cargo breakdown tables.

Production Summaries. There are two of these tables; one reflecting the actual data history and the other projecting the sustained mobilization workload. The tables can be accessed via use of the arrow keys or by typing [F5] A157 and [F5] A174, respectively. These tables provide a succinct analysis of the cargo breakdown tables, yielding arithmatic means and percentages by cargo type and by aircraft type. A similar summary for surge mobilization data is not necessary as all required data is reflected in the first month's cargo breakdown table. The results calculated in the production summaries and the mobilization portion of template table 2 are used by other template tables in calculating expected truck handlings, MHE utilization, and similar information.

Airfield Capability Analysis. This table can be accessed by typing [F5] BK1 or by using the arrow keys to position the cursor at cell BK1. For this table, users must input the most conservative airfield MOG for each aircraft type and the mobility requirement (by aircraft type) in aircraft per day (ACPD). Users will note that this table includes a preset entry of 20 in cells reflecting productive hours available. This assumption is standard throughout the template. The basis of this assumption is that only 20 out of every 24 hours is productive; allowing for shift briefings, rest breaks, shift changes, etc. Cursory analysis of this table will reveal any obvious shortfalls that may exist in aircraft parking; however, due to unusual loading/off-loading procedures (i.e., engine running on/offloads) no firm conclusions should be made based on this table alone.

Analysis of Airfield Capability. Access to this table can be gained by typing [F5] BK18 or using the arrow keys to reach cell BK18. No direct user interface is required for this table; rather the table calculates the airfield capability (in ACPD) based upon the mean aircraft on/offload times and the minimum ground times. Analysis of this table yields knowledge of airfield parking shortfalls. However, interpretation of this and all results obtained by this methodology, should be tempered with sound judgement and a qualitative assessment of specific installation procedures and characteristics.

Aircraft Handling Data. To access this table, type [F5] BW18 or use the arrow keys to position the cursor at cell BW18. For this table, users must enter the mean (average) on/offload time (depending on the analysis being performed) for each type of aircraft. When obtaining mean times (or mean data of any type) users should remember that the larger the sample size used in the computation, the more accurately the mean will reflect actual data. The minimum ground times are preset and are based on current MAC standards. To change the preset entries, refer to the subtopic in this entitled "Protecting/'Unprotecting' Cells".

Pallet Storage and Handling Facilities. To access this table, type [F5] BK32 or use the arrow keys to position the cursor at cell BK32. Completing this table requires entry of loose cargo, breakbulk build-up, and pallet storage dimensions in terms of pallet capacity and square footage. No analysis of this table is required. The data input will be used in later calculations and as a baseline comparison when determining if adequate storage and handling space exists for handling the expected surge and sustained mobilization workload.

Truck Handling Facilities. This table begins at cell BK44 and can be accessed using the arrow keys or by typing [F5] BK44. Completion of this table requires entry of the number of truck docks available for performing cargo loading/unloading operations. Entries in this table are

used in other template tables to determine if an adequate number of truck dock facilities exist to receive the expected number of trucks in support of surge and sustained mobilization operations.

Import/Export Freight Truck Data. Located in cells BK57 through BS70, this table can be accessed by using the arrow keys to position the cursor at cell BK57 or by typing [F5] BK57. Users must input the number of truck docks capable of receiving specific truck types. This data, like the data in template table 14, is used to determine the numerical adequacy of the installation's truck dock facilities.

Truck Dock Receiving Capability. This table is located in cells BU57 through CK66 and can be accessed via positioning the cursor at cell BU57 with the arrow keys or by typing [F5] BU57. Users must input the mean on/offload times for flatbeds and vans. Based on the number of docks and the mean on/offload times, the table calculates the truck dock capacity in terms of trucks per day (TPD). Those results will later be used as a comparative reference to determine if there is an adequate number of docks to receive the expected truck workload.

Truck Workload Data - Standard. Accessed by typing [F5] BK73 or by using the arrow keys to position the cursor at cell BK73, this table (and template tables 18 and 19) is essential to successful throughput capability assessment. User entries required for the outbound template include the

total months and total days sampled to obtain subsequent entry of the total number and weight (tons) of pallets, rolling stock, and breakbulk pallets, and the number of vans and flatbeds received in support of that cargo. The inbound template requires entry of the total tonnage received. From that data, the expected number of vans and flatbeds is calculated. Calculations accomplished in this table are used to estimate the workload (cargo and truck) expected during surge and sustained mobilization operations. Assumptions made (in concurrance with HQ MAC/TRKA personnel and test base "experts") to facilitate calculations accomplished in template tables 17, 18, and 19 were:

1. The standard tons per van is 3.

2. The maximum number of pallets per flatbed is 4.

3. The standard number of pieces per breakbulk pallet is 30.

4. The standard weight per pallet is 1.75 short tons.

Truck Requirement Data - Surge. Typing [F5] BS73 or using the arrow keys to position the cursor at cell BS73 grants access to this table. The only user input required is the total tonnage expected during surge mobilization operations. From that number and the results of calculations in template table 17, the number of pallets and rolling stock (and total tons of each) expected using the 80:20 rule (80% of cargo will be palletized, 20% will be rolling stock) is calculated. Because cargo preparation is a user responsibility during surge mobilization operations,

it is assumed that no breakbulk pallets will be handled. The results of calculations made in this table are used to determine the expected truck workload and the number of pallets and rolling stock per aircraft type.

Truck Requirement Data - Sustained. This table begins at cell CA73 and can be accessed by typing [F5] CA73 or by using the arrow keys to position the cursor at cell CA73. Calculations in this table are based upon the results obtained in template tables 9 and 17 (Sustained Production Summary and Standard Truck Workload). It should be noted, however, that the tonnage figure reflected in template table 9 is based upon 50% of the surge mobilization tonnage entered in template table 16 (Truck Requirement Data - Surge). Information resulting from calculations in this table also yields the expected truck workload during sustained operations.

Computer Workload - Standard. This table can be accessed by typing [F5] BK117 or by using the arrow keys to position the cursor at cell BK117. No user interface is required. Instead, the preset entries are used in calculating the computer time required to support standard operations. The assumptions made to determine the preset entries were:

1. Entering data into the computer requires 45 seconds per line item.

2. Entering data for each breakbulk pallet requires 22.5 minutes.

Further, the computer uses the pallet, breakbulk, and rolling stock data entered or calculated in template tables 8, 9, 17, 18, and 19. Preset entries are also included, reflecting the time it takes to load plan each type of aircraft.

Analysis of Computer Capability. Accessed by typing [F5] BY117 or by arrowing to cell BY117, this table requires entry of the total number of computer terminals available and the in-commission rate of those terminals. Using those entries, calculations are made to determine the total computer productive hours available.

Computer Workload - Mobilized. This table can be accessed by typing [F5] BK136 or by using the arrow keys to position the cursor at cell BK136. Similar to template table 20, calculations made in this table result in the total number of computer hours required to support surge mobilization operations. No user interface is required, as data entered or obtained in other template tables is used.

Material Handling Equipment. This table begins in cell BK153 and can be accessed using the function 5 ([F5]) key or the arrow keys. Users must input the total number of each type MHE assigned (actual and mobilized), off station, and in maintenance. Using that data, the availability and in-commission rate of each type MHE are calculated.

Elevated Transport Vehicle System (ETV) Analysis. Because the test base used to design the analysis model

used an ETV pallet movement and storage system, that subsystem was included as part of the templates. Many, in fact most, installations do not have such a system. For those installations, users should enter a zero in all cells not relevant to the installation. For installations with a similar system, entries required include the total number of single and dual pallet movers, the in-commision rates, the storage capacity, and minimum and maximum movement times (in hours) per pallet in support of various inbound and outbound pallet movement operations. Calculations performed in these tables yield the ETV productive hours and the ETV storage capacity available. It should be noted that this system is not used during surge mobilization operations, thus no template table is required.

<u>Analysis of 40K Loader Requirement</u>. This table, located in cells BK254 through DC270 can be accessed by typing [F5] BK254 by or using the arrow keys to position the cursor at cell BK254. No user interface is required as data entered or obtained in previous template tables is used. Calcula- tions accomplished in this table result in the total 40K Loader productive hours required to support standard and mobilized operations. Calculation of sustained operations productive hours required is not necessary because the cargo handled will be within the range of standard and surge mobilization operations; thus the productive hours required will also be within that range.

Analysis of 40K Loader Capability. Located in cells BK272 through CA284, this table can be accessed with the function 5 ([F5]) key or the arrow keys. Users must enter the total round trip transit time from the cargo terminal to the aircraft. Results of calculations made in this table reflect the total 40K Loader productive hours available at three preset in-commission rates (71%, 87%, and 100%) and under maximum productive hour conditions of 20 and 24. Using the actual in-commission rate of the 40K Loader system as obtained in template table 25 (MHE DATA), analysts can determine the approximate number of productive hours available at the current in-commission rate. Next, comparing the available productive hours to the required productive hours (determined in template table 34), analysts can identify existing and potential 40K Loader fleet shortfalls.

Analysis of 10K Forklift Requirement - Standard, Sustained, and Surge Mobilization. Beginning in cells BK287, BW287, and BK304 respectively, these tables can be accessed via use of the function 5 ([F5]) key or the arrow keys. User entries include the mean time required to perform various operations requiring the use of a 10K forklift. That data, combined with aircraft data and pallet data entered or obtained in template tables 9, 17, 18, and 19, allows template calculation of the 10K productive hours required under standard, sustained, and surge operations.

Analysis of 10K Forklift Capability. This table, located in cells BK335 through BU347, can be accessed by typing [F5] BK335 or by using the arrow keys to position the cursor at cell BK335. No user interface is required. Like table 34 (Analysis of 40K Loader Capability), this template table provides the 10K productive hours available at three preset in-commission rates (71%, 87%, and 100%) under maximum daily productivity hours of 20 and 24. Using the actual in-commission rate for the 10K forklift fleet (calculated in table 25), analysts can determine the productivity range applicable to the unit at the current in-commission rate. Comparing the resulting available productivity hours to the hours required (computed in template tables 35 through 37), analysts can identify existing and potential shortfalls in the 10K forklift fleet.

Analysis of 4K Forklift Requirements - Standard and Sustained. These tables begin in cells BK335 and BY335 respectively and can be accessed via use of the function 5 ([F5]) key or the arrow keys. User input is limited to the mean time required to load/offload a van. Data entered and obtained in template tables 9, 10, 19, 20, and 21 are then used to calculate the 4K forklift productive hours required during standard and sustained mobilization operations.

Analysis of 4K Forklift Capability. This template table is located in cells BK350 through CA374 and can be accessed using the function 5 ([F5]) key or the arrow keys. As

with template tables 34 and 38, this template table provides the productive hours available for this subsystem under three preset in-commission rates (71%, 87%, and 100%) and at two levels of maximum productive hours. Using the in-commission rate of the 4K forklift fleet (obtained in template table 25), analysts can determine the appropriate range of productive capability of the fleet. Comparing that number to the required hours (obtained in template tables 39 and 40) existing and potential 4K forklift fleet shortfalls can be determined.

Analysis of Widebody Loader Requirement. Located in cells BK365 through CY374, this table can be accessed using the function 5 ([F5]) key or the arrow keys. Users must input the mean round trip transit time from the cargo terminal to the aircraft. Using data obtained in template tables 1, 9, 19, and 20, the required widebody loader hours are calculated for both standard and surge mobilization operations.

Analysis of Widebody Loader Capability. This table begins at cell BK377 and can be accessed using the function 5 ([F5]) key or the arrow keys. Like template tables 34, 38, and 40, this template table provides the widebody loader productive hours available under three preset in-commission rates (71%, 87%, and 100%) and at two levels of maximum productive hours. Using the in-commission rate of the widebody loader fleet (obtained in template table 25),

analysts can determine the appropriate range of productive capbility of the fleet. Comparing that number to the required hours (obtained in template tables 39 and 40), existing and potential widebody loader fleet shortfalls can be determined.

Template File Interpretation

Interpretation of the results of the assessment is simplified via the Installation Daily Capability Summary. Each template file (inbound and outbound) contains this summary table. After all data has been entered into a template and recalculation has been accomplished, this table will reflect the requirement and capability of each subsystem under standard, surge mobilization, and sustained mobilization conditions. When interpreting any of the tables (including data tables), the following key points should be remembered:

1. All mobilized/surge mobilized results are based on a worst case scenario. For example, the aircraft handling subsystem results are based on minimum ground times for mobilized/surge mobilized conditions, yet the standard results are based on the mean on/offload times. In most cases, an installation can on/offload an aircraft in less time than the authorized ground time.

2. No qualitative factors are accounted for in the results. For example, the templates do not indicate that 25K loaders can be used to augment the 40K fleet for certain aircraft types. Therefore, an identified shortfall in the 40K fleet may not be a true limiting factor.

Because this table is a summary of all the template tables, users do not have to refer to any other table to analyse the installation's capability. To access this

table, type [F5] E195 or use the arrow keys to position the cursor at cell E195. Interpreting both the inbound and outbound summary tables is accomplished the same way. As the initial purpose of this thesis was to verify the capability of the Needham Methodology to assess the air outbound capability of an installation, the outbound summary will be used in this section to illustrate interpretation techniques. Copies of the data-filled outbound and inbound files as computed with test base data, are reflected in Tables 1 and 2.

The first column of the summary lists the subsystems analyzed by the template. Though listed individually, they are also catagorically organized by function. The first five subsystems listed all pertain to flightline operations. The next three reflect facility subsystems, and the remaining five are MHE/equipment subsystems.

The second column of the table, Standard Capabilty, defines the capability of each subsystem under current (standard) operations. The third column, Standard Requirement, defines the current requirement of each subsystem. Analysts can determine subsystems with existing or potential shortfalls by comparing these two columns. If any subsystem's requirement exceeds the capability, that subsystem is a weak link and corrective actions should be taken.

TABLE 1

INSTALLATION DAILY CAPABILITY SUMMARY - OUTBOUND

SUBSYSTEM	STANDARD CAPABILITY	STANDARD REQUIREMENT	MOBILIZED CAPABILITY	MOBILIZED REQUIREMENT	SUSTAINED REQUIREMENT
C-130 HANDLING	2.71	.30	3.70	2.00	1.00
C-141 HANDLING	257.25	9.49	155.20	28.00	14.00
C-5 HANDLING	137.27	7.23	34.92	9.00	4.50
WIDE BODY HANDLING	1.57	.87	.74	2.00	1.00
NARROW BODY HANDLING	.13	.07	.74	2.00	1.00
FLATBED DOCKS	52.04	46.02	52.04	173.71	51.13
VAN DOCKS	89.94	79.53	89.94	0.00	121.32
PALLET STORAGE	558.33	184.11	558.33	694.86	204.51
40K LOADER HOURS *	84.00	76.52	140.00	241.61	N/A
10K FORKLIFT HOURS *	408.00	79.72	408.00	220.98	107.37
4K FORKLIFT HOURS *	240.00	91.46	240.00	0.00	655.14
WIDEBODY LOADER HRS	80.00	4.35	80.00	13.34	N/A
COMPUTER HOURS *	519.84	119.69	619.81	16.48	N/A

*NOTE: AT CURRENT IN-COMMISSION RATE AND A 20 HOUR PRODUCTIVE DAY

TABLE 2

INSTALLATION DAILY CAPABILITY SUMMARY - INBOUND

SUBSYSTEM	STANDARD CAPABILITY	STANDARD REQUIREMENT	MOBILIZED CAPABILITY	MOBILIZED REQUIREMENT	SUSTAINED REQUIREMENT
C-130 HANDLING	2.71	.30	3.70	2.00	1.00
C-141 HANDLING	257.25	9.49	155.20	28.00	14.00
C-5 HANDLING	137.27	7.23	34.92	9.00	4.50
WIDE BODY HANDLING	1.57	.87	.74	2.00	1.00
NARROW BODY HANDLING	.13	.07	.74	2.00	1.00
FLATBED DOCKS	52.00	46.03	52.00	173.71	51.97
VAN DOCKS	89.97	79.64	89.97	0.00	119.19
PALLET STORAGE	558.33	184.11	558.33	694.86	207.89
40K LOADER HOURS *	84.00	76.52	140.00	241.61	N/A
10K FORKLIFT HOURS *	408.00	93.48	408.00	220.98	120.29
4K FORKLIFT HOURS *	240.00	91.59	240.00	0.00	643.64
WIDEBODY LOADER HRS	80.00	4.35	80.00	13.34	N/A
COMPUTER HOURS *	519.84	119.69	619.81	9.34	N/A

*NOTE: BASED ON IN-COMMISSION RATE AND A 20 HOUR PRODUCTIVE DAY

Column four defines the mobilized capability of each subsystem, similar to the Standard Capability but the calculations are based on equipment and facilities available under mobilized conditions. The Mobilized Requirement, column five, reflects the tasking of each subsytem under mobilized conditions. If a subsystem requirement exceeds its capability, a potential shortfall exists. For example, the Summary indicates that the test base must handle two each wide and narrow body aircraft per day. The mobilized handling capability of each of those subsystems is .74 aircraft per day. Thus a <u>potential</u> shortfall exists. The port commander should take corrective actions to insure a bottleneck does not occur when the wide and narrow body aircraft are on the ground. One possible fix could be to insure that all aircraft arriving before a wide or narrow body plane are uploaded expeditiously with early departures occuring when possible. This solution, however, could cause ramp parking or aircraft handling problems at downline stations. Regardless of the corrective action taken, higher headquarters should be notified that a problem might exist.

Column six, Sustained Requirement, reflects the tasking of each subsystem under sustained mobilization operations. Those requirements were calculated based on 50% of the mobilized requirement. As with all preset entries, that 50% figure can be changed to better reflect the tasking at an individual installation. To alter that or any other preset

entry, refer to the subtopic in this chapter "Protecting/'Unprotecting' Cells".

Comparing each subsystem requirement in column six with the capability of that subsystem (column four), analysts can identify existing or potential shortfalls under sustained mobilization conditions. If the requirement exceeds the capability, corrective actions should be taken.

Test Base Conclusions and Recommendations

Review of the Installation Daily Capability Summary reveals that there are several subsystems with potential shortfalls. Those subsystems include the handling capability of both wide and narrow body airdraft, the truck capacity of both flatbed and van docks, pallet storage area, the 40K fleet, and the 4K fleet. Each of those shortfalls is adressed individually below.

During mobilized operations, a shortage of 1.36 ACPD exists (reference table one) for both wide and narrow body aircraft (2 - .74 = 1.36). However, the aircraft parking plan at the test base is extremely flexible and with proper advance planning (e.g., ensuring aircraft arrive on schedule and encouraging early departures) the shortfall should not be a limiting factor. Nevertheless, the port should advise higher headquarters that a potential problem might exist.

The shortage of truck docks could cause severe truck backlog problems resulting in delayed truck offloads and delayed aircraft onloads. Those delays could, in turn, delay

the aircraft departures and lead to ramp saturation. As reflected in Tables 3 through 5, the docks are currently capable of handling a total of 141.98 trucks per 20 hour productive day under maximum loading times (the capability of the docks can be summed because all docks are capable of handling all truck types; thus 52.04 + 89.94 = 141.98 TPD). Therefore, a shortage of 31.73 TPD exists under mobilized conditions and 30.47 TPD during sustained mobilization operations. However, <u>if</u> the mean truck offloading time occured without fail, a total capability of 657.78 TPD would exist (241.11 + 416.67 = 657.78) and there would be no shortfall under any conditions (reference Table 5, column 7). Because "ideal" conditions cannot be counted on to occur during mobilization operations, arrangements should be made to procure mobile docks or build additional docks in the cargo terminal. A "what-if" analysis is provided in the next section of this chapter to illustrate the effects of additional docks on truck dock capacity.

Pallet storage capacity is also identified as a shortfall (see Table 1). In actuality, the shortfall exists only in covered pallet storage. The installation has unlimited space outdoors that could be used as an overflow storge site. Identification of the covered area problem is, important, because arrangements should be made to insure that an adequate amount of dunnage is on hand to support the excess 136.53 pallets per day (694.86 - 558.33 = 136.53 PPD).

TABLE 3

TRUCK HANDLING FACILITIES

OPERATION	TRUCK CAPACITY
TRUCK DOCKS:	--
RECEIVING	21
EXPORT	12
TOTAL	33.00

TABLE 4

EXPORT FREIGHT TRUCK DATA

TYPE TRUCK	# RECEIVING DOCKS AVAILABLE*	
	ROUTINE OPS	EXPANDED OPS
FLATBED	21	33
SEMI/VAN TRAILER	21	33
TMO TRUCK	21	33
COMMERCIAL TRUCK	21	33
PICK-UP TRUCK	21	33
OTHER	21	33

* NOTE: ALL DOCKS CAN HANDLE ALL TYPE TRUCKS

TABLE 5

TRUCK DOCK RECEIVING CAPABILITY

TYPE TRUCK	CAPACITY	REQ.	MEAN OFFLOAD TIME/TRUCK	MAXIMUM OFFLOAD TIME/TRUCK	PRODUCTIVE TIME	MINIMUM CAPE PER DAY	MEAN CAPE PER DAY
FLATBED	33.00	46.02	.75	3.35	20.00	52.04	241.11
SEMI-VAN	33.00	79.53	1.15	5.40	20.00	89.94	416.67

The summary also indicates that a shortfall of 101.61 40K productive hours per day exists (241.61 - 140 = 101.61 hours/day). Though this is important, it should be pointed out that the installation has 7 25K loaders (in-commission rate 100%) that are available to augment the 40K fleet (as reflected in Table 9). Therefore, the 40K fleet should not be considered a limiting factor.

A severe shortage of 415.14 4K productive hours per day is also identified in the summary (655.14 - 240 = 415.14 hours/day). This shortage exists only under sustained mobilization conditions, as there is no measurable requirement under mobilized conditions. (4Ks are used at this installation primarily for transporting breakbulk cargo; there is no identified breakbulk requirement during surge mobilizations because cargo is generally transported with, and in support of, a specific unit.) Though 10K forklifts can sometimes be used supplement the 4K fleet, a shortfall of at least 307.77 hours still exists (220.98 - 107.37 = 113.61 excess 10K hours; 415.14 - 107.37 = 307.77 hours needed). Arrangements should be made to procure additional 4K (or comparable) assets during sustained mobilization operations. A what-if analysis concerning the 4K fleet shortage is presented in the next section of this chapter.

Sensitivity ("what-if") Analyses Using the Template Files

In addition to allowing baseline assessment of an installation's capability, this model allows users to perform "what-if" analyses to determine the readiness effects of changes in the installation's assets or in the mobility scenario. The what-if possibilities are endless and description of all the possibilities is beyond the scope of this work. To illustrate the power of the model, however, a facility-related and an MHE-related "what-if" analysis are presented.

Currently, the outbound summary table indicates a total truck dock shortfall of 31.73 hours under mobilized conditions and 31.47 hours under sustained mobilization conditions. As recommended earlier in this chapter, additional truck docks should be built or procured to alleviate the shortfall. Tables 3, 4, and 5 reflect the current status of the docks. Those tables are similar to, and reflect the same information as outbound template tables 14, 15, and 16. After experimenting with different inputs for template tables 14 and 15, it was determined that a total of 41 docks are needed to alleviate the dock deficiency under mobilized conditions. The results of that change are reflected in Tables 6, 7, and 8. This change would also alleviate the shortfall that exists under sustained mobilization conditions, as shown below:

TABLE 6

TRUCK HANDLING FACILITIES

'ERATION	MAXIMUM TRUCK CAPACITY
TRUCK DOCKS:	--
RECEIVING	29
EXPORT	12
TOTAL	41.00

TABLE 7

EXPORT FREIGHT TRUCK DATA

TYPE TRUCK	# RECEIVING DOCKS AVAILABLE*	
	ROUTINE OPS	EXPANDED OPS
FLATBED	29	41
SEMI/VAN TRAILER	29	41
TMO TRUCK	29	41
COMMERCIAL TRUCK	29	41
PICK-UP TRUCK	29	41
OTHER	29	41

* NOTE: ALL DOCKS CAN HANDLE ALL TYPE TRUCKS

TABLE 8

TRUCK DOCK RECEIVING CAPABILITY

TYPE TRUCK	CAPACITY	REQ.	MEAN OFFLOAD TIME/TRUCK	MAXIMUM OFFLOAD TIME/TRUCK	PRODUCTIVE TIME	MINIMUM CAPE PER DAY	MEAN CAPE PER DAY
FLATBED	41.00	46.02	.75	3.35	20.00	64.66	299.56
SEMI-VAN	41.00	79.53	1.15	5.40	20.00	111.74	517.68

Mobilization requirement = 173.71 hours

Sustained mobilization requirement = 172.45 hours.

"What - If" capability = 64.66 + 111.74 = 176.4 hours.

Again, however, it should be remembered that the summary tables reflect the capability under worst case conditions. By thoroughly scrutinizing template table 16 (Table 5 in this chapter), it is apparent that if truck offloads were kept at the mean or below, an adequate number of docks exist. The port commander must consider all conditions and determine if additional docks are warranted.

A shortage of 415.14 4K forklift productive hours exists under sustained mobilization operations. Tables 9,10, and 11 reflect the current capability. Before manipulating the model, it was noted that the in-commission (VIC) rate for 4Ks is extremely low (63.16% as reflected in Table 9). The first corrective action that should be taken is to increase the VIC of the fleet. For example, a VIC of 87% may not be unreasonable. Currently, with 19 4Ks available under mobilized operations (Table 9) the capab- ability at an 87% VIC would be 330.6 productive hours/day (Table 11). A shortfall would still exist under those conditions (655.14 - 330.6 = 324.54 hours needed). Therefore, additional 4Ks are needed. By increasing the number of 4Ks available to 38 (Table 12), the capabilty increases to 661.2 productive hours/day; just enough to alleviate the shortfall if an 87% VIC is maintained (Table 13).

TABLE 9

MATERIAL HANDLING EQUIPMENT

ITEM	NUMBER ASSIGNED	# OFF STATION	ITEM	# IN MAINT	NUMBER AVAIL	IN-COMMISSION RATE	MOBILIZED # ASSIGNED
25K LOADER	7	2	25K LOADER	0	5	100.00%	7
40K LOADER	10	1	40K LOADER	3	6	70.00%	10
4K FORKLIFT	19	0	4K FORKLIFT	7	12	63.16%	19
6K FORKLIFT	0	0	6K FORKLIFT	0	0	.00%	0
10K FORKLIFT	24	2	10K FORKLIFT	7	15	70.83%	24
LOWER LOBE	--	--	LOWER LOBE	--	--	---	--
LOADER	0	0	LOADER	0	0	.00%	0
PAX STAIR	--	--	PAX STAIR	--	--	---	--
TRUCK	8	2	TRUCK	1	5	87.50%	8
SINGLE-	--	--	SINGLE-	--	--	---	--
PALLET ETV	2	0	PALLET ETV	0	2	100.00%	2
DUEL-	--	--	DUEL-	--	--	---	--
PALLET ETV	2	0	PALLET ETV	0	2	100.00%	2
WIDE BODY	--	--	WIDE BODY	--	--	---	--
LOADER	8	2	LOADER	4	2	50.00%	8

TABLE 10

ANALYSIS OF 4K FORKLIFT REQUIREMENT -- SUSTAINED MOBILIZATION

ACTIVITY	TRIPS *	TIME REQ/ TRIP (HRS) **	TOTAL TIME (HRS)
TRANSPORT BRKBLK FROM TRUCKS TO BUILD-UP	--- 121.32	--- 5.40	--- 655.14
TOTAL	121.32	5.40	655.14

* NOTE: BASED ON MEAN VANS/DAY
** NOTE: MAXIMUM VAN OFFLOAD TIME

TABLE 11

ANALYSIS OF 4K FORKLIFT SUBSYSTEM CAPABILITY

# ASSIGNED		IN-COMMISSION RATE	EXPECTED # AVAILABLE		PRODUCTIVE TIME	HOURS AVAILABLE	
STD	MOBILIZED		STD	MOBILIZED		STD	MOBILIZED
19	19	71%	13.49	13.49	20.00	269.80	269.80
19	19	71%	13.49	13.49	24.00	323.76	323.76
19	19	87%	16.53	16.53	20.00	330.60	330.60
19	19	87%	16.53	16.53	24.00	396.72	396.72
19	19	100%	19.00	19.00	20.00	380.00	380.00
19	19	100%	19.00	19.00	24.00	456.00	456.00
19	19	63%	12.00	12.00	20.00	240.00	240.00

TABLE 12

MATERIAL HANDLING EQUIPMENT

ITEM	NUMBER ASSIGNED	# OFF STATION	ITEM	# IN MAINT	NUMBER AVAIL	IN-COMMISSION RATE	MOBILIZED # ASSIGNED
25K LOADER	7	2	25K LOADER	0	5	100.00%	7
40K LOADER	10	1	40K LOADER	3	6	70.00%	10
4K FORKLIFT	19	0	4K FORKLIFT	7	12	63.16%	38
6K FORKLIFT	0	0	6K FORKLIFT	0	0	.00%	0
10K FORKLIFT	24	2	10K FORKLIFT	7	15	70.83%	24
LOWER LOBE	--	--	LOWER LOBE	--	--	---	--
LOADER	0	0	LOADER	0	0	.00%	0
PAX STAIR	--	--	PAX STAIR	--	--	---	--
TRUCK	8	2	TRUCK	1	5	87.50%	8
SINGLE-	--	--	SINGLE-	--	--	---	--
PALLET ETV	2	0	PALLET ETV	0	2	100.00%	2
DUEL-	--	--	DUEL-	--	--	---	--
PALLET ETV	2	0	PALLET ETV	0	2	100.00%	2
WIDE BODY	--	--	WIDE BODY	--	--	---	--
LOADER	8	2	LOADER	4	2	50.00%	8

TABLE 13

ANALYSIS OF 4K FORKLIFT SUBSYSTEM CAPABILITY

# ASSIGNED			EXPECTED # AVAILABLE			HOURS AVAILABLE	
STD	MOBILIZED	IN-COMMISSION RATE	STD	MOBILIZED	PRODUCTIVE TIME	STD	MOBILIZED
19	38	71%	13.49	26.98	20.00	269.80	539.60
19	38	71%	13.49	26.98	24.00	323.76	647.52
19	38	87%	16.53	33.06	20.00	330.60	661.20
19	38	87%	16.53	33.06	24.00	396.72	793.44
19	38	100%	19.00	38.00	20.00	380.00	760.00
19	38	100%	19.00	38.00	24.00	456.00	912.00
19	38	63%	12.00	24.00	20.00	240.00	480.00

Increasing the fleet to 38 literally doubles its size. However, this increase is only needed during sustained mobilization operations. If additional 4Ks (or comparable MHE) are not procured, a severe truck offload backlog would results, ultimately causing the delayed departure of aircraft. Table 14 reflects the summarized results of the sensitivity analysis.

Summary

This chapter described the procedures necessary for using the computerized application of the Needham methodology. First, a brief description of the model was given. That review was followed by instructions for using and interpreting the model. The results of entering test base data into the templates and recommendations to correct noted deficiencies were also presented. Those recommendations were followed by an example of the "what-if" capability of the model. Chapter VI of this thesis presents a discussion on some of the advantages and limitations of the model, provides additional conclusions, and makes recommendations for further research.

TABLE 14

INSTALLATION DAILY CAPABILITY SUMMARY - OUTBOUND

SUBSYSTEM	STANDARD CAPABILITY	STANDARD REQUIREMENT	MOBILIZED CAPABILITY	MOBILIZED REQUIREMENT	SUSTAINED REQUIREMENT
C-130 HANDLING	2.71	.30	3.70	2.00	1.00
C-141 HANDLING	257.25	9.49	155.20	28.00	14.00
C-5 HANDLING	137.27	7.23	34.92	9.00	4.50
WIDE BODY HANDLING	1.57	.87	.74	2.00	1.00
NARROW BODY HANDLING	.13	.07	.74	2.00	1.00
FLATBED DOCKS	64.66	46.02	64.66	173.71	51.13
VAN DOCKS	111.74	79.53	111.74	0.00	121.32
PALLET STORAGE	558.33	184.11	558.33	694.86	204.51
40K LOADER HOURS *	84.00	76.52	140.00	241.61	N/A
10K FORKLIFT HOURS *	408.00	79.72	408.00	220.98	107.37
4K FORKLIFT HOURS *	240.00	91.46	240.00	0.00	655.14
WIDEBODY LOADER HRS	80.00	4.35	80.00	13.34	N/A
COMPUTER HOURS *	519.84	119.69	619.81	16.48	N/A

*NOTE: AT CURRENT IN-COMMISSION RATE AND A 20 HOUR PRODUCTIVE DAY

VI. CONCLUSIONS

Introduction

Accurate capability assessment is vital to the success of the United States military forces. By ensuring that both the operational and support sectors of those forces are adequately prepared, the US is better able to win against, if not deter, worldwide military aggression. The costs involved in large scale deployments often restrict actual field testing of various mobility and operations plans. With the integration of computers, and simulation and modeling techniques into the DOD, it is commonplace to "paper test" many of those warplans as a means of saving money. Air cargo throughput capability assessment is one area of logistics where enormous strides have been made towards developing "paper test" assessment tools. The model presented in this thesis expands on the efforts of both the Captain Nancy Needham and the Transportation Engineering Agency.

Research Conclusions

Through continued and varied use and application of the MTMC throughput assessment methodology, both internal and external validity have been proven. The Needham methodology, however, was not tested using outbound throughput data; that task was accomplished via this research. Briefly, the results of inputing air outbound

cargo data into the Needham model show that installation capability assessment is viable. However, outbound validity assurance was only one of the objectives of this thesis. Further objectives were to develop a quick, reliable, easy, and meaningful means of applying the Needham formulas.

Designing speed into the application process was done by ensuring that minimal information and data gathering were needed to complete each of the two template files comprising the model. Every effort was made to ensure that data used in the template files is in the same format as the data is currently stored or otherwise recorded at the base level and HQ MAC. Additionally, updates to the model to reflect changes in facilities, MHE, warplan, etc., can be made as the changes occur; not requiring reentry of all data. This allows installation personnel to provide warplanners an up-to-date status report and facilitates better management.

The computerized application of the Needham methodology also yields a higher degree of reliability to the model, as the possibility of user calculation error are virtually eliminated. All formula cells in the spreadsheet have been protected to alleviate the possibility of inadvertant erasure or modification of a formula. However, the model may be customized to meet the needs of each individual installation. Thus, some of the generality of the methodology is reduced, thereby portraying a more accurate picture of each installation using the model.

Computerizing the model also allows easier application of the methodology. Detailed instructions for using the computerized model were written to enhance the tool's user-friendliness. VP-Planner Plus, the spreadsheet package used to build and apply the model, is compatable with most major spreadsheet packages currently used in field units. Users need only have a limited working knowledge of computers to complete the model and thus perform capability assessment. No manual calculations are required.

Conversationality, or interpretability, was the final objective of the research. That objective was accomplished via the inclusion of a summary table into each template file. Once data application is complete, the summary table reflects the capability of all subsytems analyzed. The table format allows easy comparison of installation capabilities and requirements and no other table need be interpreted. Additionally, the table prints easily onto standard 8 1/2 X 11" paper, so that it can be included in reports and facility/equipment request justification.

In sum, this model works. It has been examined by Capt John Golden (HQ MAC Plans and Programs) for possible integration into a model that simultaneously assesses cargo/passenger throughput capability and the personnel requirements associated with that workload. In addition, the model was also reviewed and validated by Capt Needham. It yields enhanced capability assessment via its ease of applicability

and accuracy. The model can be used at all .pa levels to test present and expected taskings and to provide for better allocation of equipment and facility resources.

<u>Limitations of the Methodology</u>

As with the Needham methodology, this model has some limitations. Perhaps the most significant is that it does not provide for throughput capability assessment when (as is normally the case) inbound and outbound operations occur simultaneously. Undoubtedly, this limitation could be overcome through the use of sophisticated computer simulation; however, the simplicity of application and interpretation presently offered by this model would be lost. During personal interviews conducted during the course of this research, several individuals indicated that if they couldn't understand a model they wouldn't use it. Thus, the primary value of this model is its simplicity and usability.

Additionally, it was disconcerting to find that the data available at MAC headquarters was vastly (and inexplicably) different than the "same" data maintained at the installation. Because the accuracy of output depends on the accuracy of input, a true assessment cannot be made without correct and consistent data. However, it was not the purpose of this thesis to assess the capability of one installation; rather the purpose was to develop a model that works. This model does. Further, an installation can

overcome this limitation by ensuring that an accurate six month workload data bank is maintained prior to applying this model. Additionally, installation's should realize that many warplans are developed based on data maintained by MAC. To avoid unrealistic taskings, installations should insure that MAC personnel also have access to accurate local workload data.

Further Research

As with the Needham methodology, this model does not provide for assessment of personnel requirements. Though the integration of manpower engineering techniques into the methodology would not be difficult, it was beyond the scope and purpose of this research effort. The results of such an integration would be of special benefit to installation planners and port managers in determining personnel requirements and justifying additional manning requests. Further, it would lend an air of completeness to the model, resulting in an assessment tool that judges all subsystems affecting the smooth operation of a port or deploying unit.

Additionally, the model does not currently quantify, or even consider, the effects of passenger movements on air cargo flow. Several subsystems analyzed by the model (i.e. aircraft handling and 10K forklifts) support both cargo and passenger operations. Therefore, a model that assesses both passenger and cargo throughput capability would more realistically quantify an installation's capability.

Summary

This thesis has furthered the research efforts of Capt Needham. It provides for easier, faster, more reliable quantification of an installation's throughput capability based on a methodology developed and currently used by the Military Traffic Management Command Transportation Engineering Agency. Its utility is unquestionable; allowing managers and warplanners at all levels to determine the feasibility of current and anticipated taskings, and providing quantifiable justification for altering current plans and current resource allocations.

Appendix: Glossary of Acronyms and Abbreviations

ACPD - aircraft per day

BRKBLK - breakbulk

CONUS - Continental United States

DOD - Department of Defense

HQ MAC - Headquarters Military Airlift Command

MHE - material handling equipment

MOG - maximum on ground

MTMC - Military Traffic Management Command

MTMC/TEA (TEA) - Military Traffic Management Command Transportation Engineering Agency

OPlan - Operation Plan

TEA - Transportation Engineering Agency (see also MTMC/TEA)

TPD - trucks per day

U.S. - United States

USAF - United States Air Force

VIC - vehicle in-commission

VPP - VP Planner Plus

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Abstract

Accurate capability assessment is vital to the success of the United States military forces. By ensuring that both the operational and support sectors are adequately prepared, the U.S. is better able to win, if not deter, worldwide military aggression. The costs involved in large scale deployments often restrict actual field testing of various mobility plans. As a result, it is now commonplace to "paper test" many warplans as a means of saving money. Air cargo throughput capability assessment is one area of logistics where enormous strides have been made toward developing "paper test" assessment tools.

This thesis presents an air cargo throughput capability assessment model that expands on the efforts of both the Transportation Engineering Agency and Capt Nancy Needham. It provides a computerized tool for quantifying the capability of subsystems within an air cargo transportation infrastructure.

Designed for use by managers and planners at all levels, the model is easy to apply and interpret, and requires only minimal computer hardware, software, and knowledge. The model can be used to test the air cargo transportation feasibility of existing or proposed operation and mobility plans. Additionally, results obtained from application of this model can be used as quantifiable justification for additional equipment and facilities requests and for the reallocation of existing resources.

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